Additive Manufacturing of Low Cost Upper Stage Propulsion Components

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ABSTRACT

NASA is currently developing Additive Manufacturing (AM) technologies and design tools aimed at reducing the costs and manufacturing time of regeneratively cooled rocket engine components. These Low Cost Upper Stage Propulsion (LCUSP) tasks are funded through NASA's Game Changing Development Program in the Space Technology Mission Directorate. The LCUSP project will develop a copper alloy additive manufacturing design process and develop and optimize the Electron Beam Freeform Fabrication (EBF3) manufacturing process to direct deposit a nickel alloy structural jacket and manifolds onto an SLM manufactured GRCop chamber and Ni-alloy nozzle. In order to develop these processes, the project will characterize both the microstructural and mechanical properties of the SLM-produced GRCop-84, and will explore and document novel design techniques specific to AM combustion devices components. These manufacturing technologies will be used to build a 25K-class regenerative chamber and nozzle (to be used with tested DMLS injectors) that will be tested individually and as a system in hot fire tests to demonstrate the applicability of the technologies. These tasks are expected to bring costs and manufacturing time down as spacecraft propulsion systems typically comprise more than 70% of the total vehicle cost and account for a significant portion of the development schedule. Additionally, high pressure/high temperature combustion chambers and nozzles must be regeneratively cooled to survive their operating environment, causing their design to be time consuming and costly to build. LCUSP presents an opportunity to develop and demonstrate a process that can infuse these technologies into industry, build competition, and drive down costs of future engines.